water facts

No. 11

Yield of a Water Supply Well

The amount of water that a water supply well can produce is important for choosing the correct size pump and meeting the well owner's water needs.

Well Yield

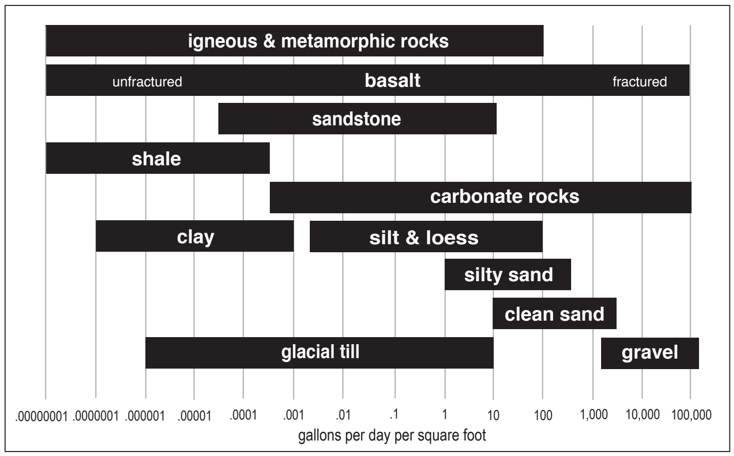
The amount of groundwater that can be obtained from a water well depends on the characteristics of the geologic formation, construction of the well, and pump.

Characteristics of the Geologic Formation

The geologic formation is the material in which the water is stored and which provides water to the well when a gradient toward the well is created. The amount of groundwater stored in the formation and the quantity of water that can flow through the formation when a gradient is created are both determined by the physical characteristics of the geologic material. An aquifer composed of sand that is all the same size can store and transmit large quantities of groundwater. In contrast, a geologic formation of fractured rock can store and transmit only limited amounts of groundwater.

Every geologic formation or rock material has a different hydraulic conductivity. Hydraulic conductivity is a measure of the amount of water that can flow through a square foot or square meter of rock under a certain head. Hydraulic conductivity is roughly equivalent to permeability.

Figure 1
Hydraulic Conductivity of Selected Rocks



(after Heath 1983)

Figure 1 shows the range of hydraulic conductivity for various rock types. The hydraulic conductivity is given in gallons per day per square foot of rock (bottom scale). As an example, the hydraulic conductivity of fine to coarse gravel is 1,000 to 100,000 gallons per day per square foot. Metric units can also be used.

The hydraulic conductivity determines how fast water will flow toward the well when a gradient is created by pumping water out of the well.

Construction of the Well

The well is a hole in the ground that may or may

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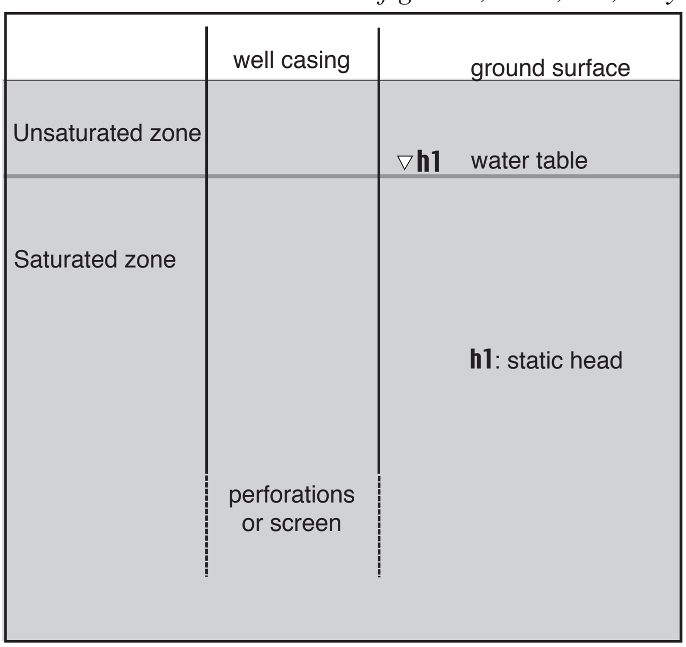
not be lined with casing. If it is cased, it may have a sand pack surrounding the casing to allow water to flow into the casing more efficiently. A properly built well will have a minimal effect on the flow of groundwater from the geologic formation into the well when the pump is turned on.

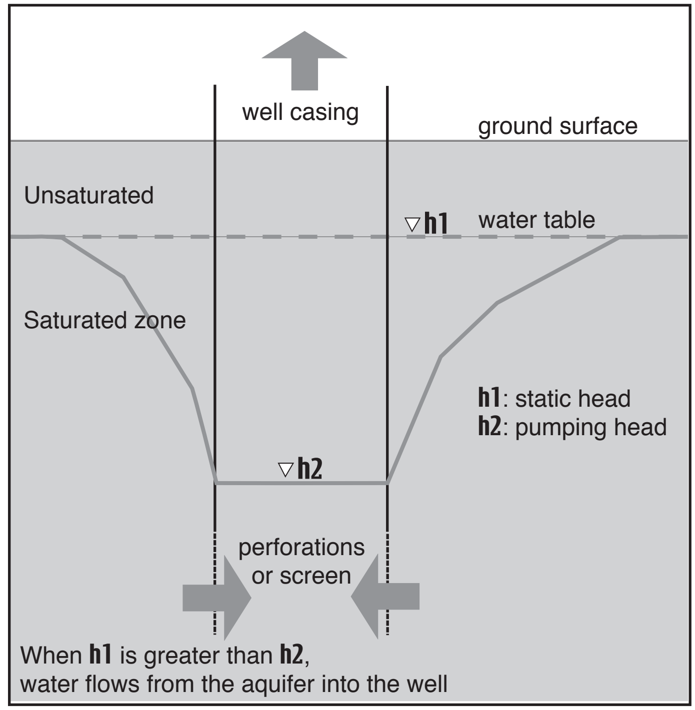
The well is like a stilling basin built into the rock or the alluvium (Figure 2). The level of water within a properly built and developed well will rise to the same level as the water in the surrounding alluvium or the same level as the water in the fractures that are penetrated by the well bore. Water in a well perforated in a confined aquifer will rise to the level of the potentiometric surface (see Water Facts 6, *Groundwater*).

Figure 2
Geologic formation that constitutes the aquifer consists of gravel, sand, silt, clay



If the pump is turned on, water within the casing or well bore is pumped to the surface, and the water level within the well is lowered (Figure 3). The lower level of water in the well creates a gradient between the geologic formation and the inside of the casing. The water level in the geologic formation is at a higher level, or head, so it begins to flow into the well through the perforations.

Figure 3
When the water level in the well creates a gradient in the geologic formation, the pump is activated



Rotary drilling methods allow a space to be left between the casing and the borehole wall. A sand pack and a surface sanitary seal can be installed in this annular space. The seal in the well prevents contaminants from entering the groundwater. The sand pack provides a transition between the sand and gravel in the formation and the openings in the perforated casing or well screen. To ensure an efficient well, the width of the perforations in the casing and the grain size of the sand pack must be properly sized by taking into account the grain size of the geologic formation.

After construction is completed, the well must be developed by surging and by washing drilling materials and finer materials out of the geologic formation and out of the well. After proper development, the sand pack prevents sand and gravel in the formation from entering the well with the groundwater when the pump is turned on. If a well pumps sand, the sand can wear out pump parts and make the water unsuitable for other uses.

In wells that are built using a cable tool drill rig, the casing is in direct contact with the geologic formation at the borehole wall. There is no annular space between the casing and the borehole wall. California's well standards require that a conductor casing be installed and be properly sealed at the surface in all cable tool wells. Similarly, all wells built using an air hammer must be properly sealed at the surface.

The Pump

The pump is the mechanical device used to push, or to lift, the water to the ground surface for use.

A correctly sized pump will provide the largest amount of water possible without lowering the water level in the well below the pump. A safety switch that shuts the pump motor off when the water falls below a certain level should be installed in wells that yield small quantities of water.

There are two basic types of pumps: variable displacement pumps and positive displacement pumps. Vertical line-shaft turbine pumps and submersible turbine pumps are examples of variable displacement pumps that are in common use today in domestic or large-capacity water wells.

Positive displacement pumps are used extensively in monitoring wells, and in hand pump and wind-powered wells. Piston pumps are used in wells powered by the wind to provide water for livestock in areas without electricity. Other types of positive displacement pumps that are used to move chemicals, slurries, or particles are plunger pumps, screw pumps and peristaltic pumps.

Well Tests and Water Use

An aquifer test conducted on a well can estimate the storage capacity of the aquifer and the rate of movement of water through the aquifer. The maximum yield of a water supply well is the maximum amount of water the well can produce continuously over a period of time, usually determined by an aquifer test.

Aquifer Test

In an aquifer test a well is pumped and the rate of decline of the water level in the pumping well and in nearby observation wells is measured. The amount of water pumped, the drawdown of water level in the wells, and the elapsed time are used to estimate how much water is stored in the aquifer and how fast the groundwater moves through the aquifer. These estimates can be used to project the water level decline when the well is pumped at various rates. Long-term drawdown can be estimated at the pumping well and at some distance from the pumping well.

Well Yield

An aquifer test determines the amount of water the well can produce, or the "yield" of the well. This information is used to choose the correct size pump to install in the well. The yield is the maximum amount of water the well can produce over a certain period of time. The yield depends on the geologic formation and the construction of the well. If water is pumped out of the well at too high a rate, water will not flow through the geologic formation fast enough to keep the well filled at a level above the pump.

Average Well Yield

When there are many wells in an area, the average yield of those wells is based on the reported yield of the wells immediately after they are built. In one county with wells only in fractured hard rock, a study showed the average well yield in the county was 10 gallons per minute (gpm) and the median yield was 13 gpm. In other fractured hard rock areas, studies have shown similar or lower yields. Average well yield in basins where large wells have been built in aquifers consisting of sand and gravel can be much higher.

In all wells, the yield is always highest right after the well has been developed. Yield begins to decline almost immediately because of clogging, encrustation, lower water levels, or sometimes, iron bacteria.

Water Use

In water resources management studies, the term "water use" refers to the amount of water actually consumed by one or more parties, or one or more communities for domestic, industrial, or agricultural purposes. In many cases the water used from a well is less than the maximum continuous long-term yield that is possible, while in other cases the use may be close to the maximum yield.

Where do you get more information?

For more information contact any of the following California Department of Water Resources offices, or see our Web site: wwwdwr.water.ca.gov.

Northern District
2440 Main Street
Red Bluff, CA 96080-2398
(530) 529-7300
www.dpla.water.ca.gov/nd

Central District
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(916) 227-7590
www.dpla.water.ca.gov/cd

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Fresno, CA 93726-6990
(559) 230-3300
www.dpla.water.ca.gov/sjd

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Glendale, CA 91203-1035
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Division of Planning and Local Assistance
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Sacramento, CA 95814-3515
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References

Alth, Max and Charlotte, rev. by S. Blackwell Duncan. 1992. *Wells and Septic Systems*. TAB Books

California Department of Water Resources. 2003 *California's Groundwater.* Bulletin 118-2003.

California Water Code

Driscoll, Fletcher. 1986. *Groundwater and Wells*. UOP Johnson Division

Heath, Ralph C. 1983. *Basic ground-water hydrology*. U.S Geological Survey, Water Supply Paper 2220 prepared in cooperation with the North Carolina Department of Natural Resources and Community Development.

Price, Michael. 1996. *Introducing Groundwater.* Chapman and Hall.

Roscoe Moss Company. 1990. *Handbook of Ground Water Development*.

U.S. Geological Survey. 1998. *Ground water and surface Water — a single resource*. Circular 1139.

________. 1999. *Sustainability of ground-water resources*. Circular 1186.

________. 2001. *Ground-water-level monitoring and the importance of long-term water-level data*. Circular 1217.